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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

DOCTRINE VERSUS CAPABILITIES:
A PROJECT MANAGER'S DILEMMA
WITH THE CH-47 HELICOPTER

STUDY PROJECT REPORT
PMC 77-2

Billy V. Genter
Major USA

FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE:

DOCTRINE VERSUS CAPABILITIES:
A PROJECT MANAGER'S DILEMMA WITH THE CH-47 HELICOPTER

STUDY PROJECT GOALS:

To look at a specific problem facing the CH-47 Modernization Project Manger. The true all weather and external capabilities of the CH-47 are limited, and it appears the modernized CH-47D will not meet the Required Operational Capabilities.

STUDY REPORT ABSTRACT:

This report examines an existing dilemma facing the CH-47 Modernization PM. The dilemma is the conflict between the tactical doctrine and the CH-47 external load capabilities, including the near term modernized capabilities.

The external load limitations are defined and future technology to improve the CH-47 capabilities is identified. Two promising external load carrying concepts are highlighted.

The primary recommendation is for the user to question if the external load NOE, all weather, day-night capability is a valid requirement.

SUBJECT DESCRIPTORS:

System Requrements Determination, Technology Base 10.01.01
Modernization and Improvement Management, Modernization 10.11.01
Terrain Flying
Helicopter External Load Operations

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DOCTRINE VERSUS CAPABILITIES:

A PROJECT MANAGER'S DILEMMA

WITH THE CH-47 HELICOPTER

Study Project Report

Individual Study Program

Defense Systems Management College

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by

Billy V. Genter
Major USA

October 1977

Study Project Advisor
Major Carlton F. Roberson, USA

EXECUTIVE SUMMARY

This report attempts to document and provide insight into an existing dilemma facing the CH-47 Modernization Project Manager. The dilemma is the apparent conflict between tactical doctrine and the CH-47 capabilities, including the near term modernized capabilities. Current doctrine calls for the CH-47 to carry external loads while terrain flying and in all-weather, day-night operations.

There are significant limitations to the CH-47 performing this combat support mission. The doctrine is examined, and the limitations to external load operations are explained. Several items of future technology are identified which will improve capabilities. The results of a significant external load limitation study are highlighted. Two promising external load carrying concepts are identified. Although one has been tested, both concepts are considered quite risky at this time.

The report concludes the modernized CH-47D will be better able to comply with the stated doctrine. It still will not be able to fly true NOE with external loads, nor will all-weather or dark night operations with sling loads be practical.

It is recommended that the user question if these capabilities are valid requirements. If the requirements are valid, then the external load concepts identified should be pursued. If they are not valid requirements, then perhaps the developer's efforts would be better directed toward internal load handling concepts.

ACKNOWLEDGEMENTS

I want to thank the personnel of the Eustis Directorate, US Army Air Mobility Research and Development Laboratory (USAAMRDL) for the working experience and education they have provided me during the past two years. I would especially like to thank those in the Military Operations Technology Division, USAAMRDL from whom I have drawn heavily for material in this report. I also want to thank Major Carlton F. Roberson, US Army, for his sound advice and editorial assistance as study project advisor.

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SECTION I

INTRODUCTION

General

In recent years, since the end of the Vietnam era, the Army aviation community has undergone a significant change in it's aviation doctrine. At the Staying Power Symposium held at Fort Rucker, Alabama in July 1975, Major General William J. Maddox, Jr. stated:

> As many of you know, the Army aviation community is now in a new regime. The game that we tactically played in Vietnam has changed. Many of us who studied the 1973 mideast war understand that the battlefield was extremely lethal. There were more tanks killed in that 20 days of war than we have in our complete stock in Europe. The same applies to losses of artillery pieces. To give these statistics more meaning, our forces in Europe have the largest standing organization prepared for combat in the United States Army. (1:1-3)[1]

Tactical doctrine is making considerable advances, especially in the employment of Army helicopters. Current doctrine states that Army helicopters will be employed and fight as a member of the combined arms team in a high threat environment. The implication is that all helicopters, regardless of type will be employed. Furthermore helicopter operations will take place around the clock and in all weather conditions. (2:1-1,1-5)

The current requirements are driving the CH-47 technology, specifically

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[1]This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The second number is the page in the reference.

in the area of external loads. This is a departure from the past, where we have frequently found a use for helicopter technology after it was developed. The chicken versus the egg concept has been used to compare helicopter doctrine versus technology. In some cases such as gunship, scout and utility helicopters, much of the technology preceeded the doctrine. Cargo helicopter technology however is currently being driven by the present tactical doctrine. See Figures 1 through 4 for artist renditions of the various helicopters in action.

Purpose

The purpose of this paper is to gain a better understanding of a current dilemma facing the CH-47 Modernization Project Manager (PM). The dilemma is the apparent external load capability limitations in complying with current doctrine, i.e. all weather, day-night, and terrain flying operations.

A major Project Manager, such as the CH-47 PM, faces many problems, dilemmas and conflicts in the course of his duties. This paper will focus on the external load limitations, and proposed concepts to overcome them. The organizational and policy interfaces between the user and developer will also be addressed. The paper will illustrate the "critical" interface between user requirements and developer capabilities to meet the requirements.

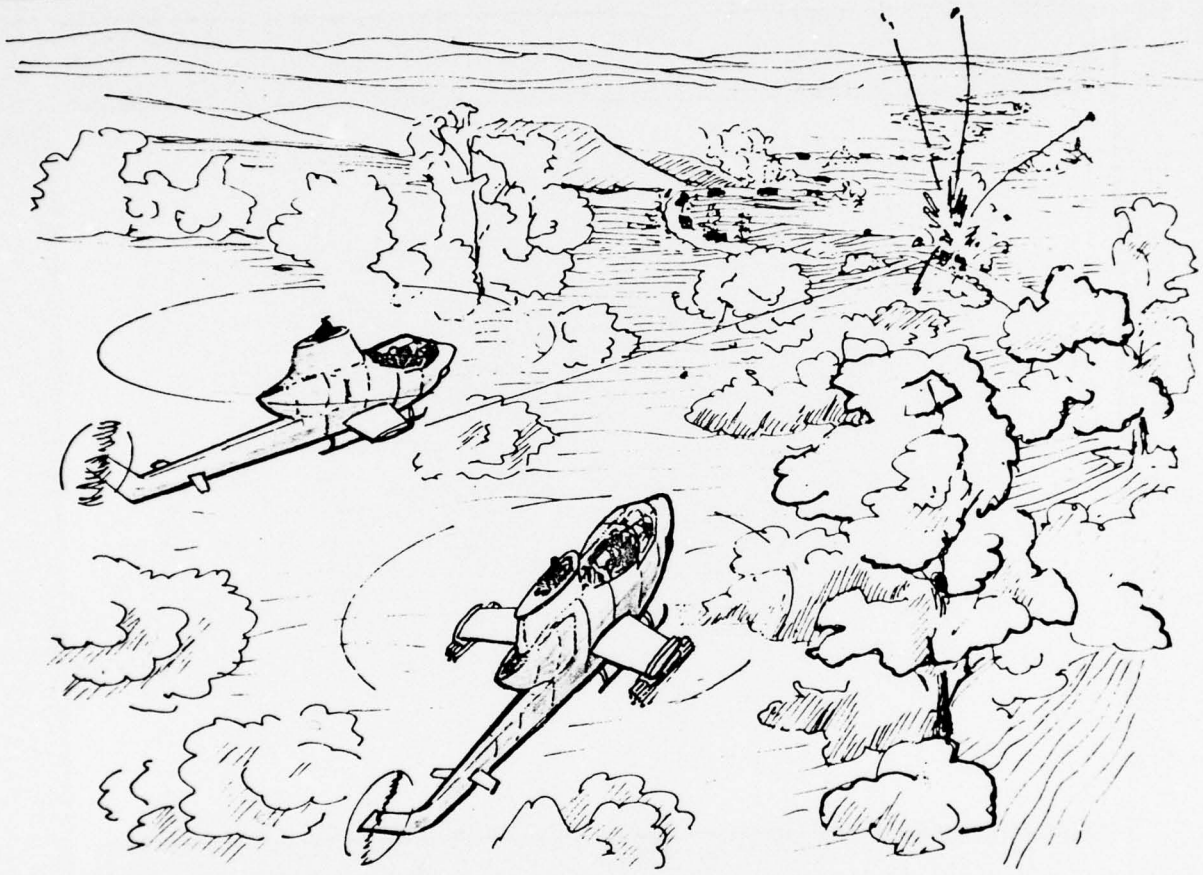

Figure 1. Gunship Helicopters (AH-1 Cobras) in action. (2:3-20)

Figure 2. Scout Helicopters (OH-58 Kiowas) in action. (2:3-51)

Figure 3. Utility Helicopter (UH-1 Huey) in action. (2:3-26)

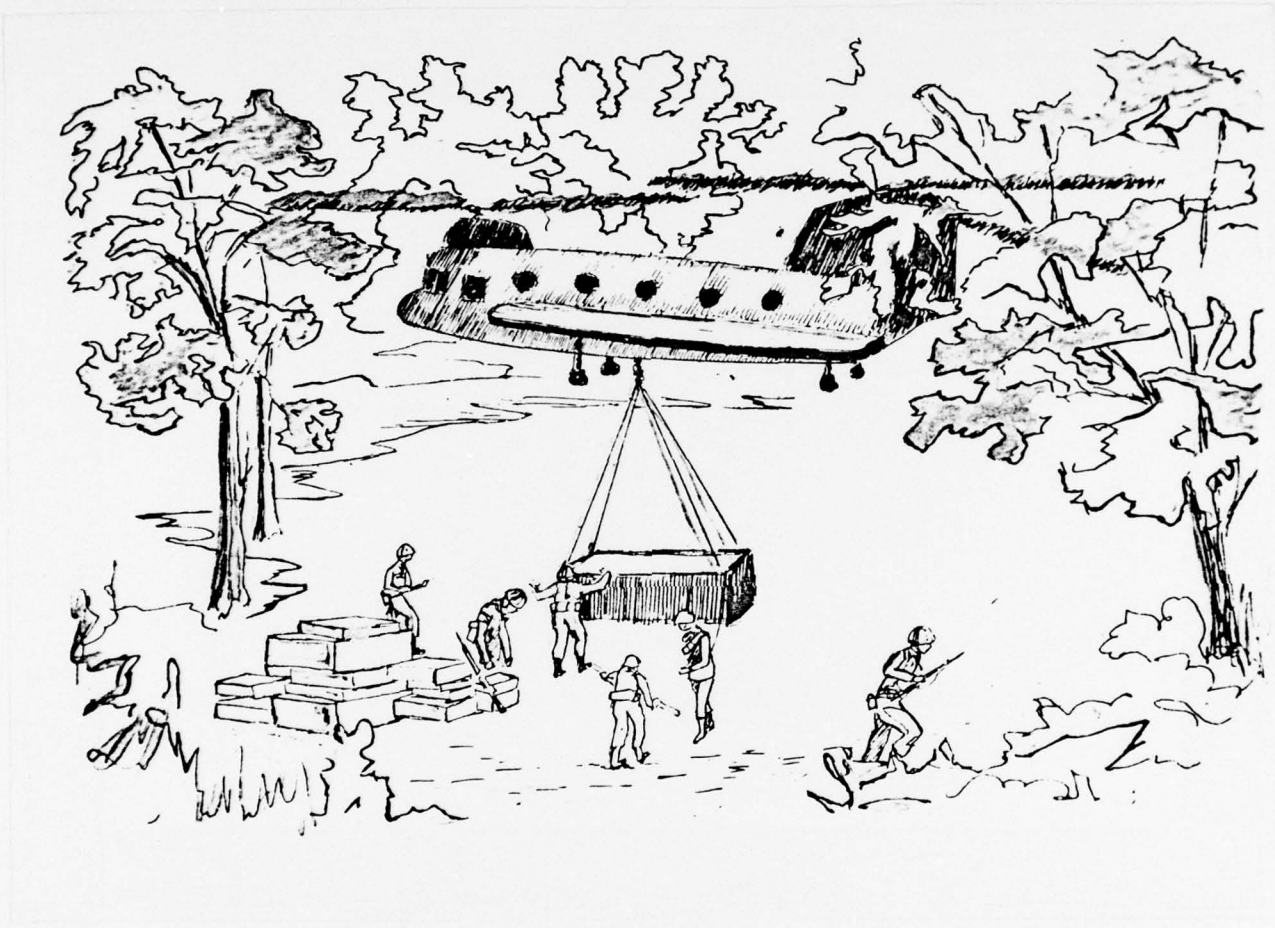

Figure 4. Cargo Helicopter (CH-47 Chinook) in action. (2:3-36)

Definitions

In recent years the Army aviation community has been using new, sometimes confusing terminology. Not only have these buzz words been confusing to those outside the aviation community, but sometimes confusing to the aviators themselves, because definitions have been changing. In order to clarify the current meanings, the following definitions are provided.

Contour flight - See Terrain flight.

High threat environment - Used to mean high air defense threat environment. It does not imply only high-intensity warfare. A high threat environment would also be present in the mid-intensity war scenario. (3:8)

Low Level flight - See Terrain flight.

Mid-intensity warfare - Conventional warfare as opposed to nuclear or insurgency warfare. Mid-intensity war would have a high air defense threat environment.

Nap-of-the Earth flight (NOE) - See Terrain flight.

Tactical instrument flying - Flight in instrument meteorological conditions (IMC) where there is an air defense threat. Current doctrine calls for instrument flight as low as 200 feet using very unsophisticated navigation aides. (4:22-2)

Terrain flight - Flight utilizing the terrain, vegetation and man-made objects to enhance survivability in a high threat environment. Terrain

flight includes low level, contour and NOE flight. See Figure 5 for comparisons. (3:5)

Contour flight - Low level flight following the contours of the earth. Generally staying masked (hidden) behind available terrain, vegetation or other obstacles. Altitude and airspeed are varied as terrain and obstacles dictate.

Low Level flight - Flight at a low altitude, generally above obstacles and at constant airspeed and altitude. Usually thought of as less than 200 feet above ground level (AGL).

Nap-of-the Earth flight (NOE) - Flight at very low altitude, remaining masked virtually at all times. Varying altitude and airspeed as necessary to get around, over and sometimes under (such as power lines) obstacles. Making maximum use of available cover.

Staying power - The capability to remain effective on the battlefield around the clock and in all weather conditions. (2:3-7)

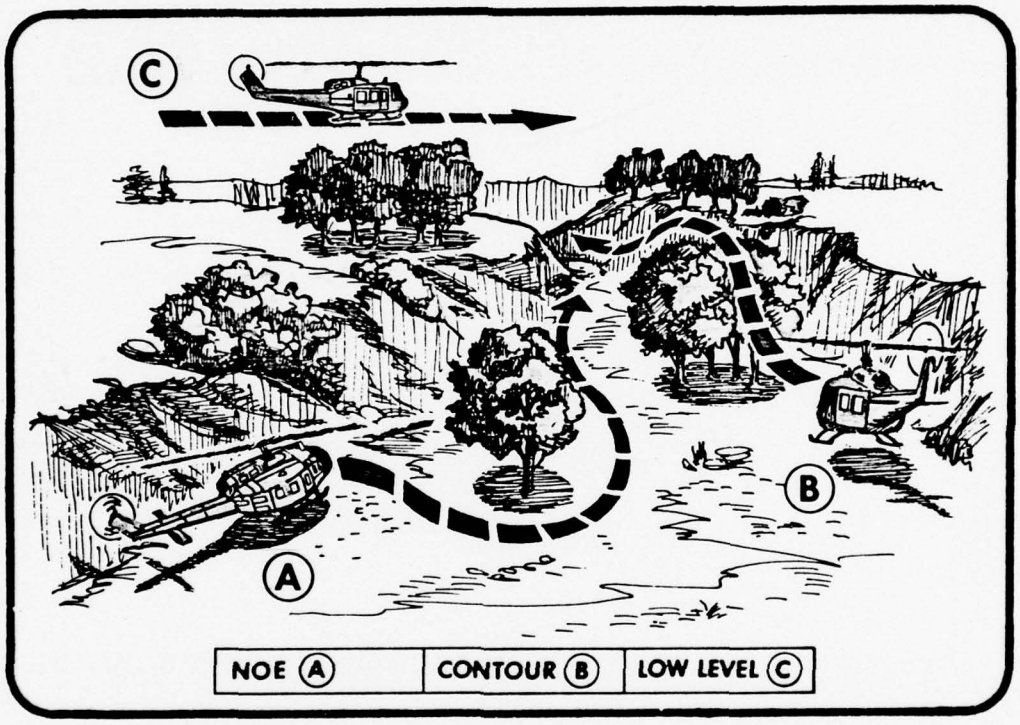

Figure 5. Terrain Flying Modes. (3:5)

Background

Although helicopters were first introduced to combat during the Korean War, the real combat proving ground was the Vietnam War. During most of the Vietnam conflict, the air defense threat consisted of small arms and automatic weapons fire. This unsophisticated threat resulted in a tactic to fly high enough to keep out of range.

Toward the end of the Vietnam War however, the threat scenario changed in some areas. Specifically the Lam Son 719 operation in 1971 and the North Vietnam offensive of 1972, exposed our helicopters to a real air defense threat for the first time. Low level or terrain flying tactics were resorted to in order to survive the threat. This tactic proved to be very successful against the more sophisticated air defenses.

The 1973 Middle East War saw an even more sophisticated air defense threat. Although the success of Middle East helicopter operations has been debated, the Israeli air superiority was unquestionably a key element in their success.(2:1-3)

Lessons learned from the latter portion of the Vietnam War and the Middle East War have led to the current doctrine of terrain flying. Any Middle East or European conflict would require this tactic to counter the known air defense threat.

During the Vietnam era, helicopters were generally employed in a fair

weather daytime environment. There were occasional night or marginal weather operations, these were not the norm however. It was rare that a short wait would not bring satisfactory weather to complete a mission under visual conditions.

An analysis of the European weather picture is a completely different story. One can expect approximately 55 days per year of severe weather and icing conditions. (1:1-6) If Army helicopters are to have the staying power required, tactical instrument flight will be required in the European scenario.

SECTION II

TACTICAL DOCTRINE

Present

As mentioned in the introduction, current Army doctrine requires terrain flying tactics to survive in a high threat environment. All weather, around-the-clock operations are required to provide the staying power needed for a successful operation in a European scenario. This doctrine applies to virtually all helicopters regardless of type.

Gunship, scout and utility helicopters have had little difficulty meeting the terrain flying requirement. Terrain flying problems have centered mainly around training. All weather and night operations have resulted in varying degrees of success for these helicopters. Problems have been encountered here in both training and helicopter capabilities, or rather lack of capabilities. Not all these helicopters are equipped for instrument flight and lack of night vision devices hinders black night terrain flight operations.

Cargo helicopters such as the CH-47, have been quite limited in these operations with external loads. Although the CH-47 is generally not expected to fly in the most lethal airspace at the Forward Edge of the Battle Area (FEBA), the aircraft does operate in forward areas. A typical mission might be to resupply or reposition a forward area refuel or rearm point as close as 15 kilometers from the FEBA.

The primary limitation to terrain flying or instrument flying with external loads is the aerodynamic instabilities of the external load.

The combat support mission of the CH-47 uses external loads as the most efficient, fastest method of transporting cargo. External loads allow movement of oversize or bulky loads too big for internal loading. It also minimizes exposure by not having to remain at the pick up or drop off site more than a few seconds to hook up or deposit the sling load.

During the Vietnam era approximately 90 percent of all cargo carried by CH-47s was carried externally. According to personnel at Fort Campbell, Kentucky, where the largest concentration of CH-47s now exists, 90 to 95 percent of all cargo is carried internally. The personnel at Fort Campbell are obviously attempting to "live" with the current terrain flying doctrine. Virtually all flying is done below 200 feet AGL, where external load operations are difficult at best. (5)

Future

The requirements were summed up very nicely by the Assistant Secretary of the Army for Research and Development, Edward A. Miller and Army Chief of Staff for Research, Development and Acquisition, LTG Howard H. Cooksey. (6)

> Requirement: Fight night or day in weather fair or foul.
>
> Requirement: Aircraft that can function and survive in a High-Density Air Defense environment.

Excellent reasons were also provided for the requirements. It was explained that 40 percent of the Warsaw Pact exercises are conducted at night, and the soldiers continually train in snow and bad weather.

As a consequence, major changes in tactical doctrine are not envisioned at the present time. However, what is predicted for the forseeable future, is technological advances in current and near term helicopters to allow them to fully live up to the stated doctrine. Envisioned are improved visionics, navigation equipment, stabilization equipment, anti-ice/de-ice equipment and new external suspension or load stabilization equipment. (2.3-35)

SECTION III

STUDIES AND TESTS CONDUCTED

General

Various studies and tests have been conducted concerning the limitations involved with terrain flying. (9) There seems to be total agreement on the fact that pilot workload is very high. Much planning and preparation is also required to successfully execute a terrain flying mission, especially an NOE flight. Furthermore, adequate training seems to overcome most problems with daytime, fair weather terrain flight.

Various studies have also been conducted concerning terrain flying at night.(7) Most of these studies have compared visually unaided flight with some form of night vision aid. There seems to be total agreement here also on the fact of the extreme pilot workload. In addition to lengthy planning as required for day flight, the pilots tend to fly slower and higher at night. This is an added safety margin due to the reduced visibility and depth perception. Obstacles such as wires are virtually impossible to see on a dark night. Another point common among the night terrain flight tests is they have all been conducted in good weather and visibility conditions, usually with the aid of moonlight or at least starlight. This writer was unable to find any studies of night terrain flying in marginal weather conditions.

In tests with Low Light Level Television (LLLTV) and Forward Looking

Infrared (FLIR) systems, tactical maneuvers were performed with varying degrees of success. In general, hover flight was quite difficult, pilots had a tendency to drift. There were also limitations with sensor mobility and field of view. Sensor mobility problems are those concerned with the ability to rapidly move the television camera or FLIR sensor laterally or vertically to view a larger area due to the limited field of view. Wires could not be detected with these systems. Since the FLIR system operates on a thermal differential principle, thermal signature depends on the heating history. Both the LLLTV and FLIR systems are very limited in a marginal weather situation.(7)

In addition to the general limitations of speed, altitude and depth perception, the night vision goggles also have the problem with field of view. Most pilots felt the 40 degree field of view was insufficient for adequate viewing. It was necessary to re-focus the goggles for instrument viewing, and glare or reflections from the cockpit were distractiong. It was also felt the goggles were very uncomfortable to wear since the added weight of the goggles applied a bending moment to the pilots head and neck.(8)

Although these vision enhancing systems provide some improvment to the unaided eye for night flight, the current state-of-the-art systems still do not equal the unaided eye in the daytime environment.

External Load Limitations

Tests or studies relating external load limitations to current tactical

doctrine are almost non-existent at the present time. There is one significant study however, completed by the Boeing Vertol Company on the CH-47. The report is still in final draft form.(9)

The Boeing Vertol study used a very sophisticated computer helicopter math model to simulate various load and sling configurations and compared the data with actual test results for verification. Various maneuvers were selected and simulated to best illustrate the different maneuvers in terrain flying. Each weight class was simulated first as internally loaded to obtain a baseline. Then the various external configurations were compared to the baseline to quantify the limitations. The simulations also compared the standard CH-47C with the single hook suspension system to the modernized CH-47D with multiple hook suspension.

The results actually quantified the limitations as to how much bank, acceleration, deceleration, etc. could be achieved with the various load configurations. Also quantified were masking heights and times to complete various maneuvers. Clearly shown was the fact that abrupt maneuvers resulted in violent load oscillations, which exceeded hook sway limits. The load oscillations could also result in fuselage strikes with the load. The increased masking heights required with external loads are fairly obvious. Perhaps not quite so obvious is the increased exposure time due to the slow gentle maneuvers required with external loads.

Another limitation quantified, is referred to as pilot induced oscilla-

tions (PIO). The PIO phenomenon may occur when load motions create longitudinal accellerations perceived by the pilot as greater than .05 g. These accelerations may give a confusing cue to the pilot, and cause him to apply corrective action in the wrong direction, causing the oscillations to diverge rather than attenuate. Pilots encountering PIO are forced to jettison the load in order to regain control of the helicopter. The susceptibility to PIO is the primary reason instrument flight is not conducted with external loads. Since flight on a very dark night offers few visual cues, it is similar to instrument flight and PIO also is the primary limitation again.(9:13)

The results of the Boeing Vertol study are not surprising to pilots experienced with external loads. Every cargo helicopter pilot knows, that with external loads all control movements and maneuvers are made slow and gentle, and instrument flight with sling loads is prohibited. The study did however quantify the limitations quite clearly, possibly for the first time. It also spelled out that the less demanding mode of terrain flight, low level flight, was well within the capabilities of the present CH-47. It was further felt that the modernized CH-47D would have no trouble in the contour mode, however a true NOE mode did not seem to be destined for the CH-47.

SECTION IV

FUTURE TECHNOLOGY

As mentioned earlier, vision enhancing systems such as night vision goggles, LLLTV and FLIR provide improved capabilities to comply with current doctrine. Future generations of these items should provide even greater capabilities. Other promising vision enhancing systems such as radar, Laser Obstacle Terrain Avoidance and Warning System (LOTAWS) and Forward Looking Microwave Radiometry (FLMRAD) are in various stages of development.

The modified CH-47, designated the CH-47D will provide several improvements to allow compliance with the stated doctrine. The advanced flight control system will improve stability and control of the CH-47, thus reducing pilot workload in external load operations. The multiple hook configuration will greatly improve load stability, allow more severe maneuvers, and greater speed with external loads. (see Figure 6).(9:68) Additionally the mutiple hook arrangement will allow mutiple addressee loads increasing productivity (see Figure7). (9:74)

The Boeing Vertol study reports that the CH-47D will provide much improved performance with the multiple hook configuration. It is pointed out however that instrument flight is still not recommended, because the possibility of PIO is still present. A previous test with a dual hook configuration demonstrated PIO quite vividly. (10:104)

Two external load handling concepts have been identified which should allow external load operations with the stability characteristics of internal loads. The first is called the Active Arm External Load Stabilization System (AAELSS). Two prototypes have been built and tested. The AAELSS concept senses load motion and through servo actuators damps the load motion. Although the concept is simple, the actual hardware is somewhat complex and heavy. See Figure 8 for artists rendition.(10:13-15)

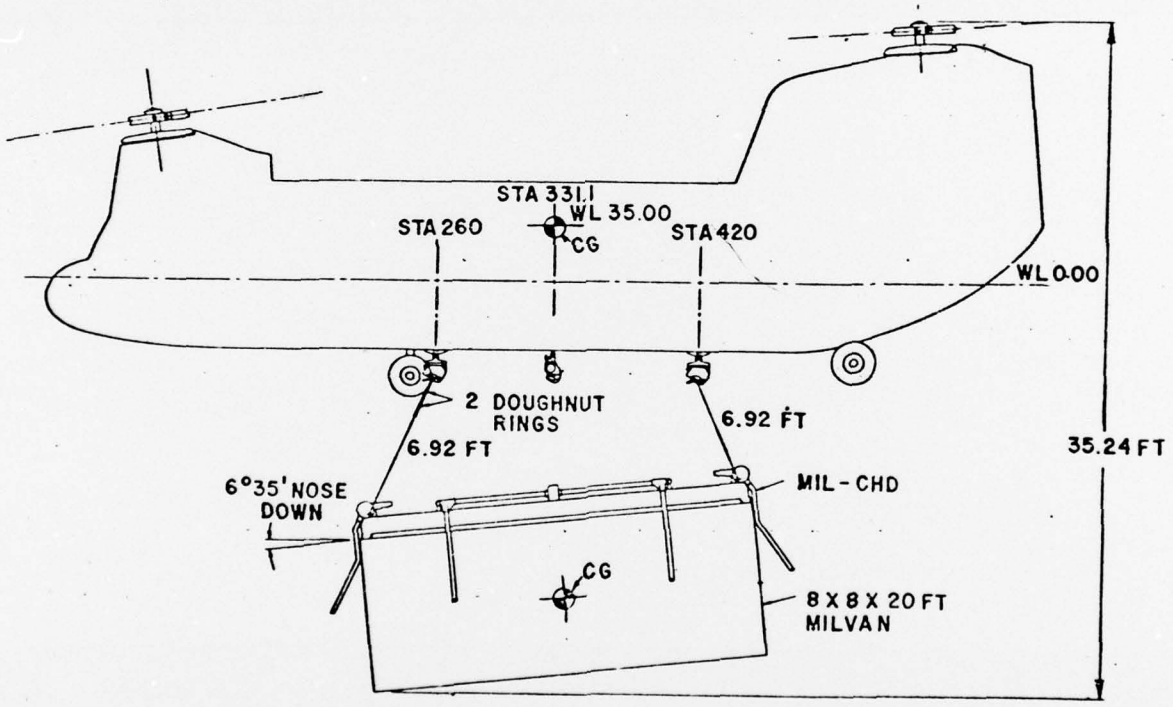

Figure 6. Dual Suspension System

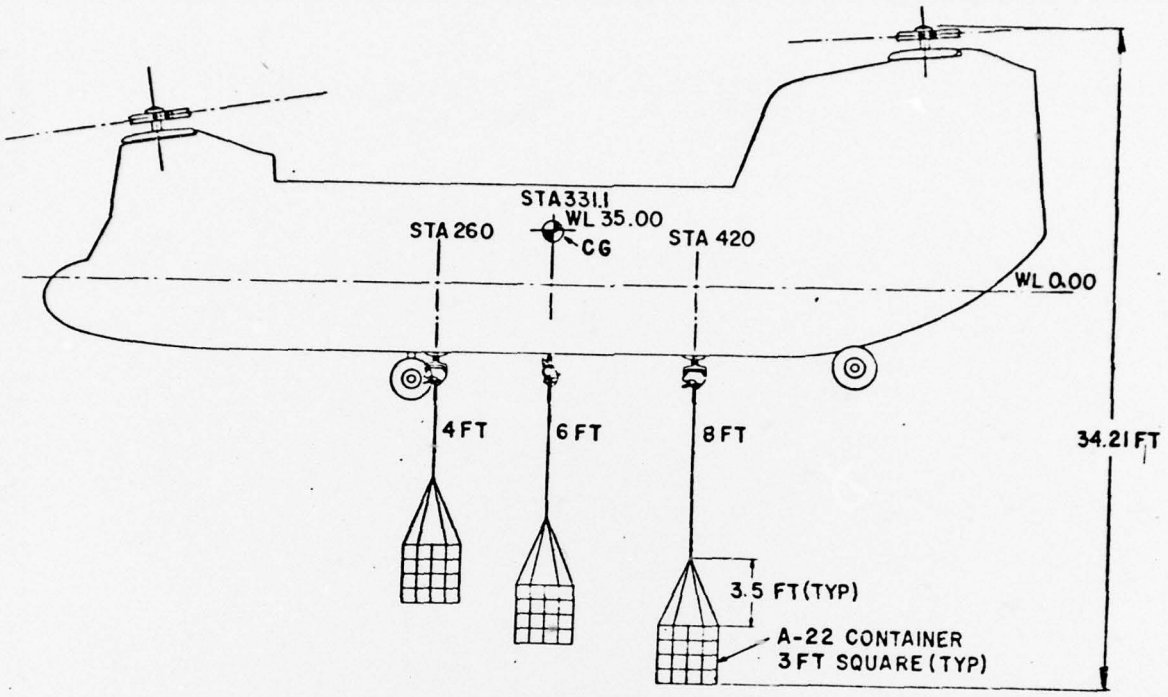

Figure 7. Multiple Addressee Loads

The second concept being investigated is a load snubbing device. This device is conceived as a lifting device to be used with a MILVAN or Gondola (an open frame device similar to a MILVAN), which would hoist and secure the load to the aircraft fuselage. See Figure 9 for artists rendition.(9:133-136) The complexity, weight, and cost of this system is still unknown since it is still in the conceptual stage.

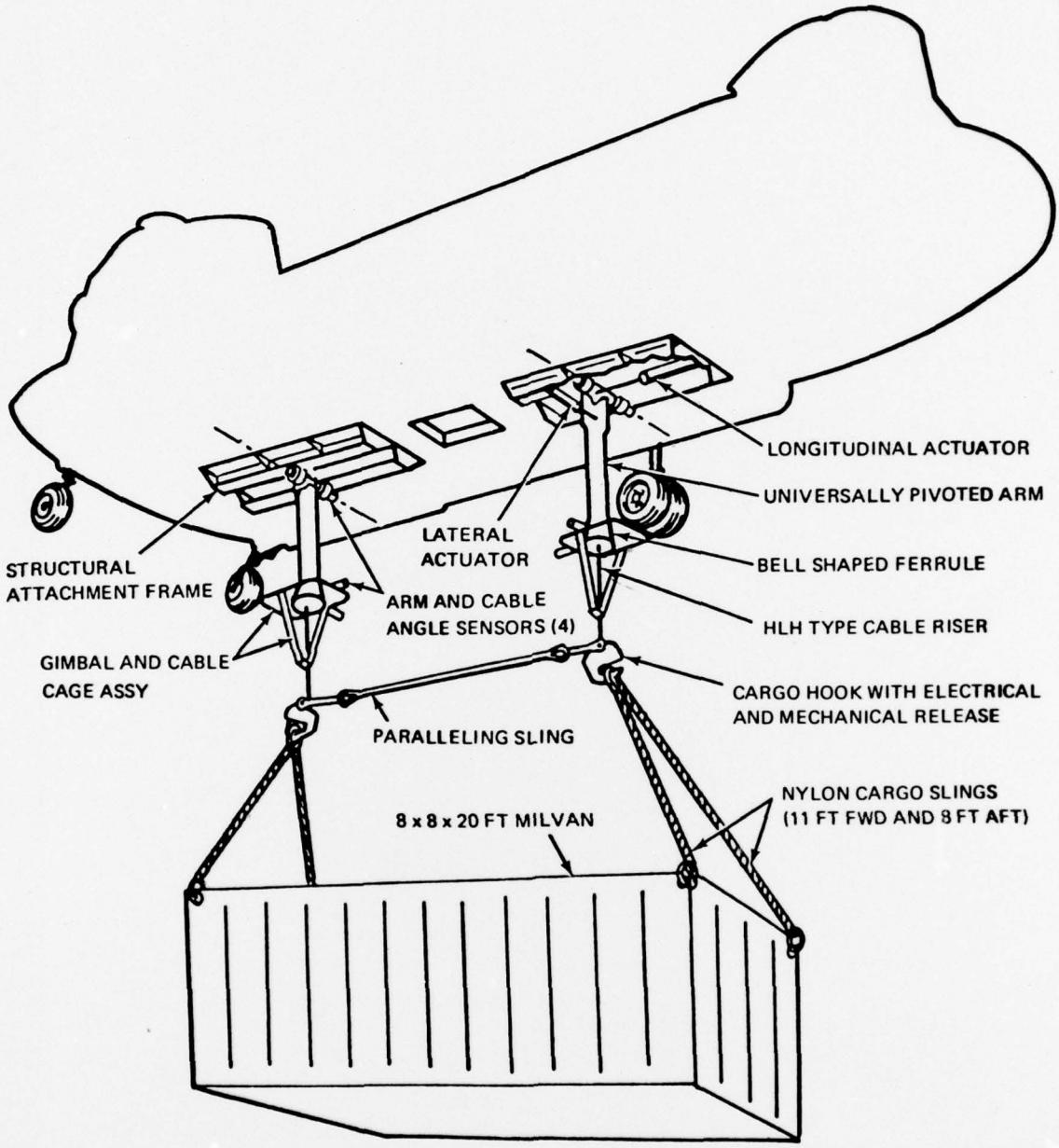

Figure 8. Active Arm External Load Stabilization System

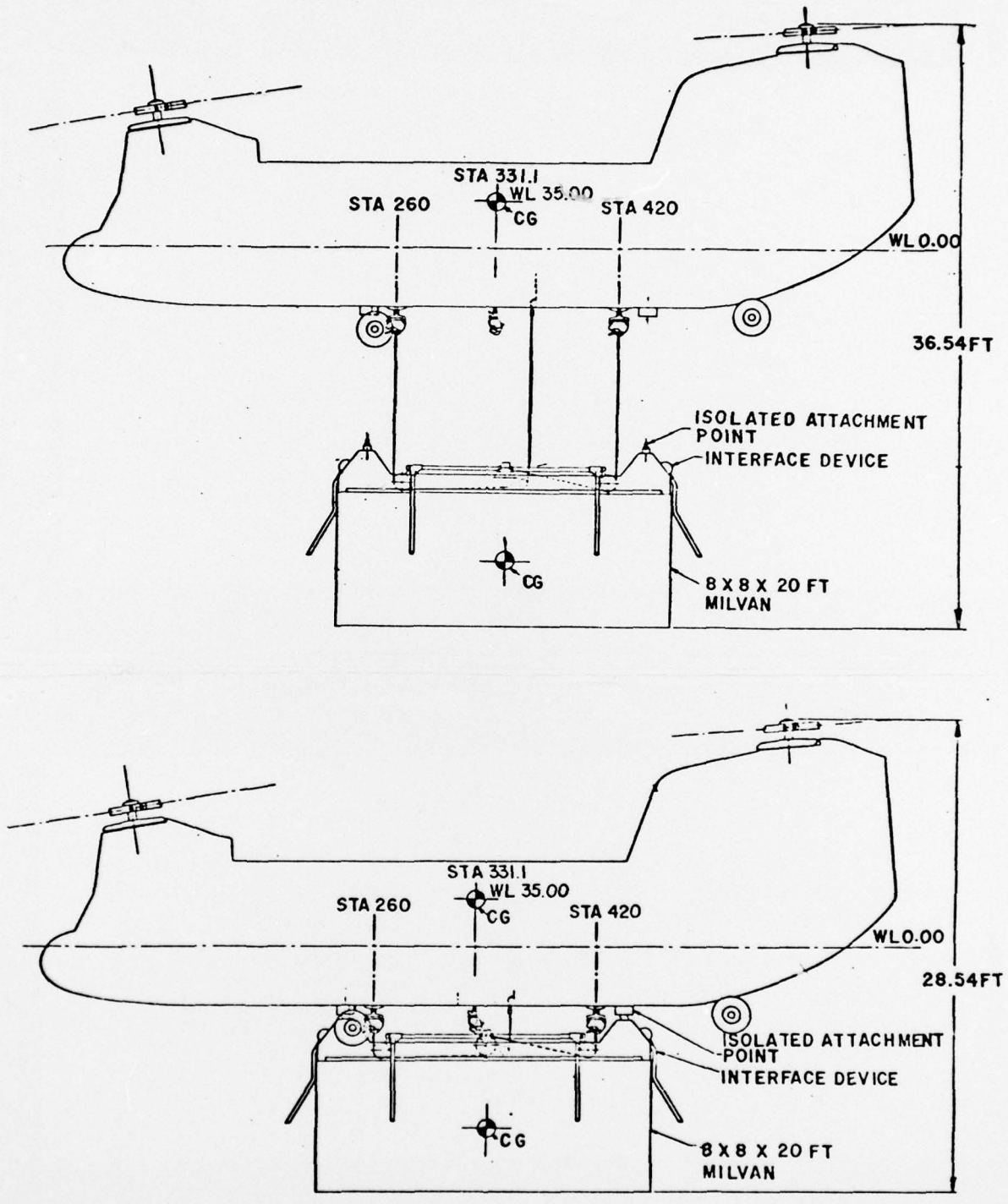

Figure 9. Load Snubbing Device

SECTION V

USER/DEVELOPER INTERFACES

A look at the User/Developer interface helps to understand the dilemma facing the CH-47 Modernization PM. Army Regulation 1000-1 states: (11:2)

> The system concept will be developed and validated jointly by the materiel developer and combat developer prior to formal commitment by the Army to the need for the system. The Required Operational Capability (ROC) document is the vehicle for securing the Army's commitment to pursue full-scale development and/or procurement of a system.

In the actual formulation of the CH-47 Modernization ROC, a Medium Lift Helicopter Special Study Group (MLHSSG) was formed. This SSG was chaired by the combat developer in the form of the Training and Doctrine Command (TRADOC) proponent for the CH-47. The SSG was vice-chaired by the materiel developer in the form of the Development and Readiness Command (DARCOM) CH-47 PM. It is interesting to note that when the CH-47 Modernization ROC was prepared, the TRADOC proponent was at Fort Rucker, Alabama, and the proponency has now been changed to TRADOC'S Combat Developments Command located at Fort Eustis, Virginia. Prior to approval of the ROC by TRADOC headquarters it was coordinated through various TRADOC and DARCOM organizations.

The portion of the approved ROC that causes the dilemma that this writer is concerned with states: (12:1)

> The modernized CH-47 medium lift helicopter will be employed

in accordance with existing operational/organizational concepts. Increased emphasis will be placed on terrain flying and night/IMC operations.

It appears that the user representative in the form of the combat developer wanted these capabilities. It seems also obvious that the materiel developer would try to provide these improved capabilities.

Among the items listed in the ROC to be modernized, the key elements to provide improved terrain flying and night/IMC capabilities are the advanced flight control system and the multi cargo hook system. Both of these systems will improve the capabilities of the CH-47, however they still will not provide full terrain flight or night/IMC capabilities while carrying external loads.

Since the proposed modernized CH-47, apparently will not solve all the user's problems, perhaps another look at the requirement is in order. While the external load improvements are only a portion of the total ROC, the pressure on the developer to provide full terrain flight or night/IMC capabilities is probably not as great as some of the other requirements. This writer feels that the user and developer should re-examine the external load requirements of the CH-47. If the full external load capabilities are not required or are too expensive either in terms of cost or added weight of a new cargo handling system, then the ROC should be changed to reflect the more realistic requirements.

Perhaps improved methods of handling internal cargo would be more realistic. If both external and internal load improving concepts are inadvisable, then the user should also take steps to modify the doctrine for cargo helicopter employment when exposed to a high threat environment.

SECTION VI

ANALYSIS AND DISCUSSION

It seems clear that the user desires the capability to carry external loads while terrain flying. The user also desires an all weather day-night capability with sling loads. It appears that the capability will not be available in the forseeable future.

Although the modernized CH-47D will provide improvements in the less demanding modes of terrain flight, NOE flight with sling loads is not indicated at the present time. Dark night and instrument flight will still be questionable, due to the possibility of pilot induced oscillations.

The two concepts identified to provide external load operations with the stability characteristics of internal loads are still quite risky. The AAELSS system prototype has been successfully tested, however the complexity and added weight causes much concern. The load snubbing device is still in the conceptual phase, and the risks are still unknown.

With these thoughts in mind, it appears the CH-47 Modernization PM's dilemma is not going to be solved in the near future. Perhaps new tactics or methods of CH-47 employment are in order.

The primary reason for desiring external load capabilities has been due to the difficulties in loading and unloading of cargo internally. Rapid

pick up and delivery of loads reduces turn around time and exposure. The secondary reason for external loads is to allow outsized loads to be carried.

One idea that has received very little emphasis in recent years is methods to rapidly load, secure and offload internal cargo. Perhaps effort in this area would be more fruitful than the external concepts. It could be beneficial, while not very costly, to at least identify rapid internal loading concepts. These concepts could then be used in a trade-off analysis with the external concepts, to determine combat effeciency and cost effectiveness.

Another question is, how valid is the user's requirement to carry external loads in all weather conditions and while terrain flying? If this question were pursued in some depth, it may result in an answer that the requirement is needed so infrequently that it is merely a nice to have capability.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

Based on the preceeding it is concluded that the CH-47 Modernization PM's dilemma is not going to be solved with the CH-47D. There will still be limitations to terrain flying with external loads, especially in NOE. A true all weather, day-night capability with sling loads will also be lacking.

It is recommended that the user and developer get together and question if these capabilities are really required or just nice to have. If the requirements are really valid then the external load concepts should be studied further and one or both pursued to deployment.

If it is determined that the full external capability is not necessary, but NOE and all weather internal operations are required, then further study of rapid internal loading and unloading concepts should be conducted.

A trade-off analysis could be conducted between external and internal loads. Such an analysis could determine which method was the most efficient or cost effective to accomplish the cargo helicopter mission.

If it is determined that the full NOE, all-weather external load mission is not required, it is further recommended that the user take steps to modify the existing ROC and update the tactical doctrine as appropriate.

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